Estimating mass discharge of contaminant plumes downstream of landfills: Benefits of geophysics

Balbarini, Nicola; Maurya, Pradip Kumar; Rønde, Vinni Kampman; Christiansen, A.V.; Bjerg, Poul Løgstrup; Klint, K.E.S.; Binning, Philip John

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Estimating mass discharge of contaminant plumes downstream of landfills: Benefits of geophysics

N. Balbarini, Technical University of Denmark
P. K. Maurya, Aarhus University
V. K. Rønde, Technical University of Denmark
A. V. Christiansen, Aarhus University
P. L. Bjerg, Technical University of Denmark
K. E. S. Klint, Geological survey of Denmark and Greenland
P. J. Binning, Technical University of Denmark

Key words: Contaminant mass discharge, landfill leachate plume, surface geophysical survey.

Geophysical methods are increasingly being employed at landfill sites to map waste deposits and leachate plumes. Surface geophysical surveys are particularly useful at large landfill sites, because these methods are able to collect extensive data sets at low cost.

It is important to evaluate the contaminant mass discharge when evaluating the environmental impact of landfills on groundwater. However, mass discharge estimation is currently infeasible at large and heterogeneous sites because of the cost of the large number of multiple sampling points required to map plumes with sufficient certainty. Here a novel contaminant mass discharge method for large and heterogeneous sources is presented, employing surface geophysical surveys with multiple sampling point data to improve mass discharge estimates and reduce drilling costs.

The aim of the study was to combine the geophysical, geological, hydrogeological, and chemical data to estimate contaminant mass discharge and then evaluate the benefit of including geophysical data.

The contaminant mass discharge is determined at a control plane located downstream from the source and perpendicular to groundwater flow. The contaminant concentration distribution and the hydraulic conductivity of the control plane are combined with the hydraulic gradient to calculate the mass discharge. The definition of the heterogeneous hydraulic conductivity and contaminant concentration fields is particularly challenging. Here, the contaminant concentration distribution was mapped by using the electrical resistivity distribution from the DC (Direct Current) surface geophysical survey to guide the interpolation of water quality data from point measurements. The method is only sensitive to contaminant leachate compounds that affect the electrical resistivity. Similarly, the chargeability distribution from the IP (Induced Polarization) surface geophysical survey was employed to interpolate the hydraulic conductivity point measurements determined using slug-tests and grain size analyses.

The contaminant mass discharge method was tested at a landfill site in Grindsted, Denmark. In order to evaluate the benefits of including the geophysical data, the contaminant mass discharge was calculated using only the data from the wells, and then compared with results when both borehole and geophysical data are employed. At Grindsted landfill site, thirty-one sampling points were available along a 780 m long control plane. The heterogeneous distribution of waste disposed at the landfill, together with the size of the control plane, causes mass discharge estimation to be highly uncertain. The surface geophysical survey provided insight on the extent of the plume and on the variation in concentrations along the control plane and so reduced the uncertainty of the contaminant mass discharge estimate.

The novel method was shown to be useful when estimating contaminant mass discharge at large and heterogeneous contaminated sites, such as landfills. It requires few wells and inexpensive surface geophysical survey data. The method can be applied for landfill site risk assessment and when prioritizing site investigations and remediation.